UNITED STATES PATENT AND TRADEMARK OFFICE

UNITED STATES DEPARTMENT OF COMMERCE
United States Patent and Trademark Office
Address: COMMISSIONER FOR PATENTS
P.O. Box 1450
Alexandria, Virginia 22313-1450
www.uspto.gov

APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
10/659,803	09/11/2003	William C. Black	X-1356 US	5248

24309 7590 12/11/2007
XILINX, INC
ATTN: LEGAL DEPARTMENT
2100 LOGIC DR
SAN JOSE, CA 95124

EXAMINER	
WANG, TED M	

ART UNIT	PAPER NUMBER
2611	

MAIL DATE	DELIVERY MODE
12/11/2007	PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 10/659,803	Applicant(s) BLACK ET AL.	
	Examiner Ted M. Wang	Art Unit 2611	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE *1* MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

1)☐ Responsive to communication(s) filed on _____.

2a)☐ This action is **FINAL**. 2b)☐ This action is non-final.

3)☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

4)☐ Claim(s) _____ is/are pending in the application.

4a) Of the above claim(s) _____ is/are withdrawn from consideration.

5)☐ Claim(s) _____ is/are allowed.

6)☐ Claim(s) _____ is/are rejected.

7)☐ Claim(s) _____ is/are objected to.

8)☒ Claim(s) *1-30* are subject to restriction and/or election requirement.

Application Papers

9)☐ The specification is objected to by the Examiner.

10)☐ The drawing(s) filed on _____ is/are: a)☐ accepted or b)☐ objected to by the Examiner.

Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).

Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).

11)☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

12)☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).

a)☐ All b)☐ Some * c)☐ None of:

1.☐ Certified copies of the priority documents have been received.

2.☐ Certified copies of the priority documents have been received in Application No. _____.

3.☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

1) ☐ Notice of References Cited (PTO-892)
2) ☐ Notice of Draftsperson's Patent Drawing Review (PTO-948)
3) ☐ Information Disclosure Statement(s) (PTO/SB/08) Paper No(s)/Mail Date _____.
4) ☐ Interview Summary (PTO-413) Paper No(s)/Mail Date. _____ .
5) ☐ Notice of Informal Patent Application
6) ☐ Other: _____.

DETAIL ACTIONS

Election/Restrictions

1. Inventions 1- [Claims 9-15 and 24-30], 2 – [Claims 1-8 and 16-323] are related as combination and subcombination. Inventions in this relationship are distinct if it can be shown that (1) the combination as claimed does not require the particulars of the subcombination as claimed for patentability, and (2) that the subcombination has utility by itself or in other combinations (MPEP § 806.05(c)). In the instant case, the combination as claimed does not require the particulars of the subcombination as claimed because the presence of a claim to combination AB_{sp} does not alter the propriety of a restriction requirement properly made between combination AB_{br} and subcombination B_{sp}. Claim AB_{br} is an evidence claim which indicates that the combination does not rely upon the specific details of the subcombination for its patentability. If a restriction requirement can be properly made between combination AB_{br} and subcombination B_{sp}, any claim to combination AB_{sp} would be grouped with combination AB_{br}. Where B_{br} is the limitation of "<u>a frequency dependent load;</u>" as recited in the independent claims 9 and 24, respectively, and B_{sp} is the limitation "<u>a frequency dependent load that is adjusted based on the frequency response setting;</u>" recited in the independent claims 1 and 16, respectively.

Because these inventions are independent or distinct for the reasons given above and there would be a serious burden on the examiner if restriction is not required because the inventions require a different field of search (see MPEP § 808.02), restriction for examination purposes as indicated is proper.

$$z(t;\bar{h}) = \Big[(1+j)\cdot\sinh\Big(\frac{2}{\sigma^2}Real\{<\bar{y}(t),\bar{h}^*>(1-j)\}\Big) + (1-j)\cdot\sinh\Big(\frac{2}{\sigma^2}Real\{<\bar{y}(t),\bar{h}^*>(1+j)\}\Big)\Big]\times \Big[\cosh\Big(\frac{2}{\sigma^2}Real\{<\bar{y}(t),\bar{h}^*>(1-j)\}\Big) + \cosh\Big(\frac{2}{\sigma^2}Real\{<\bar{y}(t),\bar{h}^*>(1+j)\}\Big)\Big]^{-1} \quad \text{Equation 19}$$

In a high SNR setting, it can be shown that, in both nominator and denominator of $z(t;\bar{h})$ only one of the exponents is dominant and hence,

$$z(t;\bar{h}) \to \hat{s}(t) \quad \text{Equation 20}$$

where $\hat{s}(t)$ is the nearest neighbor to $<\bar{y}(t), \bar{h}^*>$ from the source alphabet (i.e. $\hat{s}(t)$ is the hard decision of $<\bar{y}(t), \bar{h}^*>$). In this case, the ML estimator reduces to:

$$\hat{h}_{ML} = \frac{1}{2T}\cdot\sum_{t=1}^{T}\bar{y}(t)\cdot\hat{s}(t)^* \quad \text{Equation 21}$$

which is the well known, decision directed, channel estimator.

In a low SNR setting, the ML estimator of the present invention, in effect, uses a soft symbol metric that is based on the instantaneous SNR and follows a hyperbolic law. To illustrate this, reference is now made to FIGS. 1A, 1B and 1C which graph the function in Equation 19 for several SNR values (20 dB, 10 dB and 0 dB, respectively) and for the scalar case of one active finger. Each figure shows a scatter plot of the values of $z(t;\bar{h})$ in the complex plane.

As can be seen, at the high SNR of FIG. 1A, $z(t;\bar{h})$ always takes on one of the four hard decision values (1−j), (1+j), (−1−j), (−1+j) of the received signal. This matches with Equation 20 and 21. However, at lower SNR's, $z(t;\bar{h})$ is "softened" according to the confidence of each specific hard decision. Thus, FIG. 1B (medium SNR) has values for $z(t;\bar{h})$ mostly along the real and imaginary axes and FIG. 1C (low SNR) has values for $z(t;\bar{h})$all over the complex plane.

Until now, the noise variance has been identical for all elements of the noise vector $\bar{n}(t)$. It is also possible to relax this assumption. Thus, in Equation 15 and 19, the following

$$\frac{2}{\sigma^2}Real\{<\bar{y}(t),\bar{h}^*>\ldots\} \quad \text{Equation 22}$$

is replaced by

$$2Real\{<\tilde{y}(t),\bar{h}^*>\ldots\} \quad \text{Equation 23}$$

where $\tilde{y}(t)$ is obtained from $\bar{y}(t)$ by dividing each of its components by the corresponding noise variance, i.e.

$$\{\tilde{y}(t)\}_i = \frac{\{\bar{y}(t)\}_i}{\sigma_i^2} \quad \text{Equation 24}$$

Appendix A provides a series of approximations to Equation 19 to simplify its implementation.

In some applications, such as the 3GPP wideband CDMA cellular systems, there is a continuous pilot channel separate from a traffic channel that contains data and pilot symbols. For these applications, a channel estimator based on both the traffic and the pilot channels can be constructed. The channel estimator of the present invention can be used for the traffic channel while a prior art channel estimator can be used for the continuous pilot channel. The two channel estimates can be combined to produce the final channel estimate. This provides a statistically more stable channel estimator.

Implementation

Reference is now made to FIG. 2, which schematically illustrates a channel estimator **30** of the present invention. Estimator **30** comprises a noise variance estimator **32**, an a priori symbol probability generator **34** and a channel tap determiner **36**.

Noise variance estimator **32** determines the noise variance σ^2 as described hereinbelow. There are a variety of methods, known in the art, for estimating the noise variance σ^2. One method, incorporated herein by reference, is described in the article "An Efficient Algorithm for Estimating the Signal-to-Interference Ratio in TDMA Cellular Systems", by Mustafa Turkboylari et al., *IEEE Transactions on Communications*, Vol. 46, No. 6, June 1998, pp. 728–731.

Another method of estimating the noise variance, suitable for the 3GPP wideband CDMA time slot structure, uses pilot symbols only and implements the following equations for the k-th element of the noise variance vector $\bar{\sigma}^2$:

$$\hat{\sigma}_k^2(n) = (1-\alpha)\cdot\hat{\sigma}_k^2(n-1) + \alpha\cdot\sigma_k^2(n) \quad \text{Equation 25}$$

Where the time index n is in units of slot, α is a user selectable exponential forgetting factor, and

$$\tilde{\sigma}_k^2(n) = \frac{1}{N_p}\sum_{t=1}^{N_p}\left|\frac{\bar{y}_k(t)}{G(t)}\cdot s(t)^*\right|^2 - \left|\frac{1}{N_p}\sum_{t=1}^{N_p}\frac{\bar{y}_k(t)}{G(t)}\cdot s(t)^*\right|^2 \quad \text{Equation 26}$$

where N_p is the number of pilot symbols per slot, G(t) is the receiver's automatic gain control (AGC) level (as known in the art) and $\bar{y}_k(t)$ is the k-th element of the vector $\bar{y}(t)$.

Symbol probability generator **34** receives information from higher layers in the receiver defining the type of the current symbol. For example, the higher layer may indicate that the current symbol is a pilot, a power control or a data symbol. Symbol probability generator **34** then produces the probability vector $\bar{p}(t)$ associated with the symbol type, as per Equations 2–7.

Channel tap determiner **36** determines the channel tap estimate vector by solving Equation 16. Since Equation 16 is an implicit equation, one has to resort to iterative algorithms for solving it. There are numerous iterative approaches, based on gradients and/or Hessians of Equation 16 that can be implemented. See, for example, the book *Numerical Recipes in C: The Art of Scientific Computing*, by Press et al., 2nd Edition, Cambridge University Press, 1992.

Channel estimator **30** operates in a "batch" mode, taking a sequence of T samples (where T is a user selectable parameter often related to the fading rate) and iterating until the channel estimate $\bar{h}$ is stable.

As with any iterative algorithm, an initial point must be provided for the algorithm. There are a variety of initializa-

2. The examiner has required restriction between combination and subcombination inventions. Where applicant elects a subcombination, and claims thereto are subsequently found allowable, any claim(s) depending from or otherwise requiring all the limitations of the allowable subcombination will be examined for patentability in accordance with 37 CFR 1.104. See MPEP § 821.04(a). Applicant is advised that if any claim presented in a continuation or divisional application is anticipated by, or includes all the limitations of, a claim that is allowable in the present application, such claim may be subject to provisional statutory and/or nonstatutory double patenting rejections over the claims of the instant application.

3. Applicant is advised that a reply to this requirement must include an identification of the invention that is elected consonant with this requirement, and a listing of all claims readable thereon, including any claims subsequently added. An argument that a claim is allowable is considered nonresponsive unless accompanied by an election.

Should applicant traverse on the ground that the inventions are not patentably distinct, applicant should submit evidence or identify such evidence now of record showing the inventions to be obvious variants or clearly admit on the record that this is the case. In either instance, if the examiner finds one of the inventions unpatentable over the prior art, the evidence or admission may be used in a rejection under 35 U.S.C. 103(a) of the other invention.

tion procedures. For example, one may arbitrarily set the initial $\bar{h}$ to unity and then apply the iterative algorithm to converge to the true value. Alternatively, one can apply a conventional channel estimation technique based only on pilot symbols and use its output as the initial value for $\bar{h}$.

Reference is now made to FIG. 3A, which schematically illustrates the implementation of a simple iterative solution to Equation 16 that does not require calculation of gradients or Hessians. The channel estimator **30** of FIG. **3A** is a single tap channel estimator.

In the embodiment of FIG. 3A, channel tap determiner **36** comprises a scalar z-generator **37**, a multiplier **38** and a summer **39** over a period of length T of the output of vector multiplier **38**.

Z-generator **37** receives the demodulated scalar signal y(t), the probability vector $\bar{p}(t)$ from probability generator **34**, the noise variance $\hat{\sigma}^2$ from noise variance estimator **32** and the channel estimate h' of the previous iteration. Z-generator **37** then generates the scalar value z(t;h') from Equation 15. For example, this operation can utilize a lookup table. In particular, when Equation 19 needs to be computed, a lookup table can be used which saves the need to calculate the hyperbolic sine and cosine functions.

Multiplier **38** multiplies the output y(t) with the value z(t;h') and summer **39** sums the output of multiplier **38** over a period of length T. The result is the updated channel estimate h which is then fed back to z-generator **37**.

Reference is now made to FIG. 36, which schematically illustrates the structure of a two-tap batch channel estimator of the present invention, here labeled **40**, when operating on a vector $\bar{y}(t)$ whose dimension is two. Elements similar to those of FIG. **3A** carry similar reference numerals.

Channel estimator **40** comprises noise variance estimator **32**, a z-generator **42**, two multipliers **38A** and **38B** and two summers **39A** and **39B**. Z-generator **42** receives the demodulated vector signal $\bar{y}(t)$, the probability vector $\bar{p}(t)$ from probability generator **34**, the noise variance $\hat{\sigma}^2$ from noise variance estimator **32** and the channel estimates h_i' of the previous iteration.

Z-generator **42** then generates the value z(t;h') from Equation 15. Multipliers **38A** and **38B** multiply the outputs $y_0(t)$ and $y_1(t)$, respectively, with the value z(t;h') and summers **39A** and **39B** sum the outputs of their respective multipliers **38A** and **38B** over a period of length T. Each summer **39** produces its updated channel estimate h_i, which is also fed back to z-generator **42**.

It will be appreciated that the present invention is also operative for more than two taps. The structure of the channel estimator is similar to that of FIG. **3B**.

The channel estimator of the present invention can also be implemented in a sequential (or adaptive) manner. For these implementations, the channel estimator updates the estimate one sample at a time. This amounts to finding a sequential solution to Equation 16 and it typically takes some time to converge. Adaptive solutions inherently assume a slowly time-varying channel so that channel variations can be tracked. Initialization for these implementations is as described hereinabove.

Reference is now made to FIG. **4**, which illustrates a general adaptive channel estimator **100**. Estimator **100** is similar to estimator **30** of FIG. **2** and comprises an adaptive channel tap determiner **102** in place of channel tap determiner **36**.

Adaptive channel tap determiner **102** sequentially solves Equation 27 (hereinbelow) where, for each new time instance t, a new solution is obtained.

$$\hat{h}_t = \sum_{m=1}^{t} y(m)\cdot z(m;\hat{h}_t)^* \cdot \lambda^{t-m} \qquad \text{Equation 27}$$

λ is an exponential forgetting factor. With the special choice of λ=1, Equation 27 reduces to Equation 16 up to a scalar gain.

There are a variety of sequential algorithms, two of which are presented hereinbelow.

A first approach uses anchors and linear interpolation between adjacent anchors similar to the one described in the following documents that are incorporated herein by reference:

H. Andoh, M. Sawahashi, and F. Adachi, "Channel Estimation Using Time Multiplexed Pilot Symbols for Coherent Rake Combining for DS-CDMA Mobile Radio," *Proceedings of the IEEE Vehicular Technology Conference*, 1997, pp. 954–958.

F. Adachi and M. Sawahashi, "Wideband Wireless Access Based on DS-CDMA," *IEEE Transactions on Communications*, pp. 1305–1316, July 1998.

F. Adachi, M. Sawahashi, and H. Suda, "Wideband DS-CDMA for Next Generation Mobile Communications Systems," *IEEE Communications Magazine*, September 1998.

In the prior art anchor approach, illustrated in FIG. **5** to which reference is now briefly made, the channel estimator averages a few pilot symbols from the beginning of each of a series of successive time-slots to generate a sequence of "anchors" **50** and **52**. Then, the channel estimator linearly interpolates between the anchor at the beginning of one slot to that at the beginning of the next slot to generate the channel estimates **54**.

In accordance with a preferred embodiment of the present invention, the channel estimator computes a pilot anchor $\hat{h}_p$ using the N_p pilot symbols of one time slot and a data anchor $\hat{h}_s$ using N_s data symbols, as follows:

$$\hat{h}_p = \frac{1}{2N_p}\cdot\sum_{k=1}^{N_p} \bar{y}(k)\cdot s(k)^* \qquad \text{Equation 28}$$

$$\hat{h}_s = \frac{1}{2N_s}\cdot\sum_{k=1}^{N_p} y(k)\cdot z(k;\hat{h}_p)^* \qquad \text{Equation 29}$$

where N_s is a user-defined parameter determining the number of data symbols to be used. One may set $N_s=2N_p$ so that N_p of the data symbols are taken from before the pilot symbols and N_p of the data symbols are taken from after the pilot symbols. The channel estimator then averages the two values:

$$\hat{h}_{anchor} = \frac{\hat{h}_p + \hat{h}_s}{2} \qquad \text{Equation 30}$$

The channel estimator linearly interpolates between adjacent anchors $\hat{h}_{anchor}(n-1)$ and $\hat{h}_{anchor}(n)$ to obtain the channel estimates for the n-th slot. In accordance with a preferred embodiment of the present invention, the channel estimator separately interpolates the amplitudes and phases of the adjacent anchors.

In order to improve upon the statistical variability of the anchors, the older anchor can be averaged, as follows:

4. Applicant is advised that the reply to this requirement to be complete must include an election of the invention to be examined even though the requirement be traversed (37 CFR 1.143).

5. Applicant is reminded that upon the cancellation of claims to a non-elected invention, the inventorship must be amended in compliance with 37 CFR 1.48(b) if one or more of the currently named inventors is no longer an inventor of at least one claim remaining in the application. Any amendment of inventorship must be accompanied by a request under 37 CFR 1.48(b) and by the fee required under 37 CFR 1.17(i).

Conclusion

6. Any inquiry concerning this communication or earlier communications from the examiner should be directed to Ted M. Wang whose telephone number is 571-272-3053. The examiner can normally be reached on M-F, 7:30 AM to 5:00 PM.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Chieh Fan can be reached on 571-272-3042. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see http://pair-direct.uspto.gov. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free).

Ted M Wang
Examiner
Art Unit 2611

Ted M. Wang